

# New Optics for the Tevatron

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# Orbit response matrix fit

V.Lebedev, V.Nagaslaev, A. Valishev (FNAL),  
V. Sajaev (ANL)

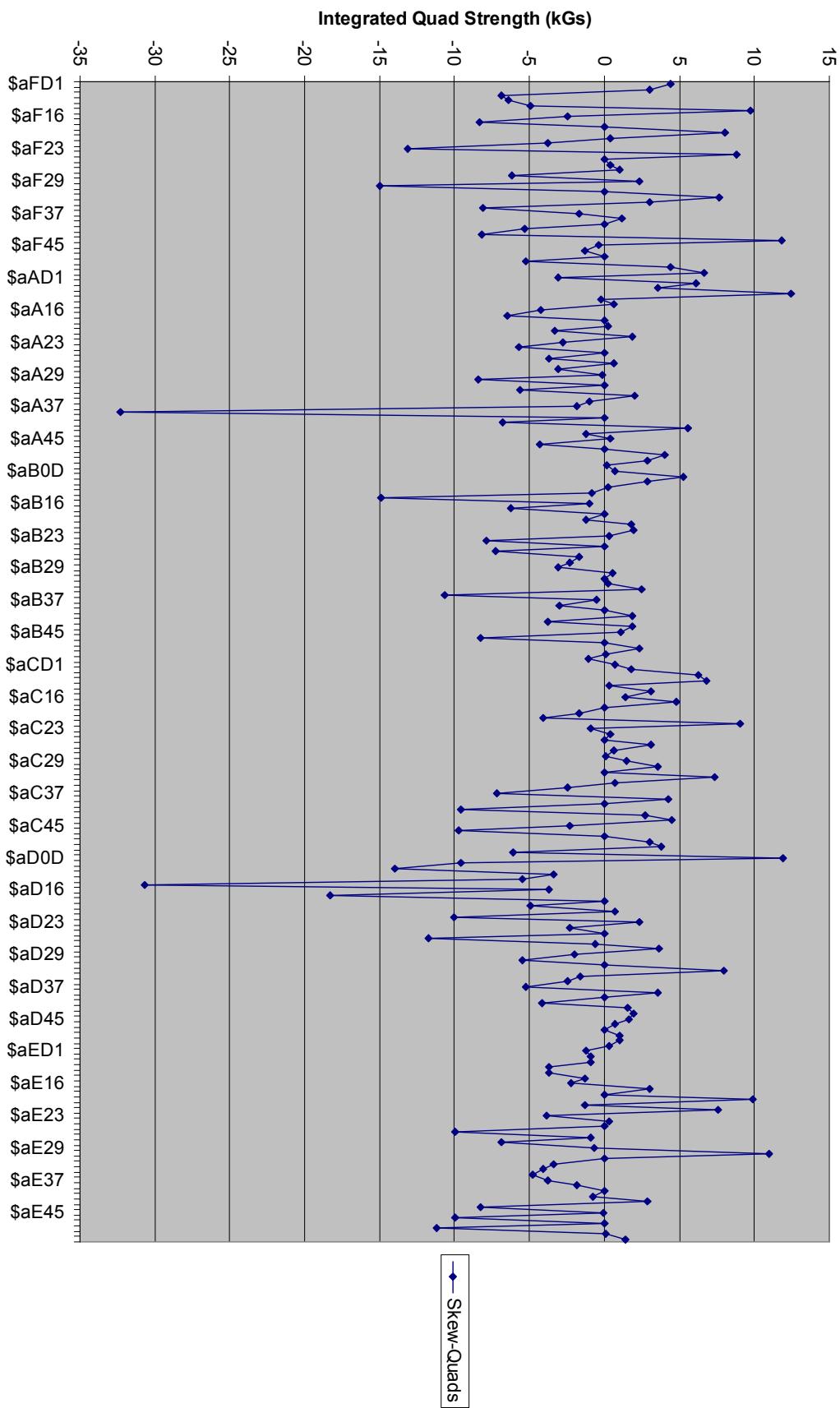
Using the differential orbit measurements and response matrix fit we find the following machine parameters:

- Quadrupole gradient errors ( $\sim 2e-3$ )
- Quadrupole tilts
- Steering magnet calibrations
- Steering magnet tilts
- BPM gains
- BPM tilts

A computer model was built based on the measurements with beta function accuracy of  $\sim 5\%$  (cross-checked with other methods)

# Skew-Quadrupole Errors

Skew-Quads



8/29/2005

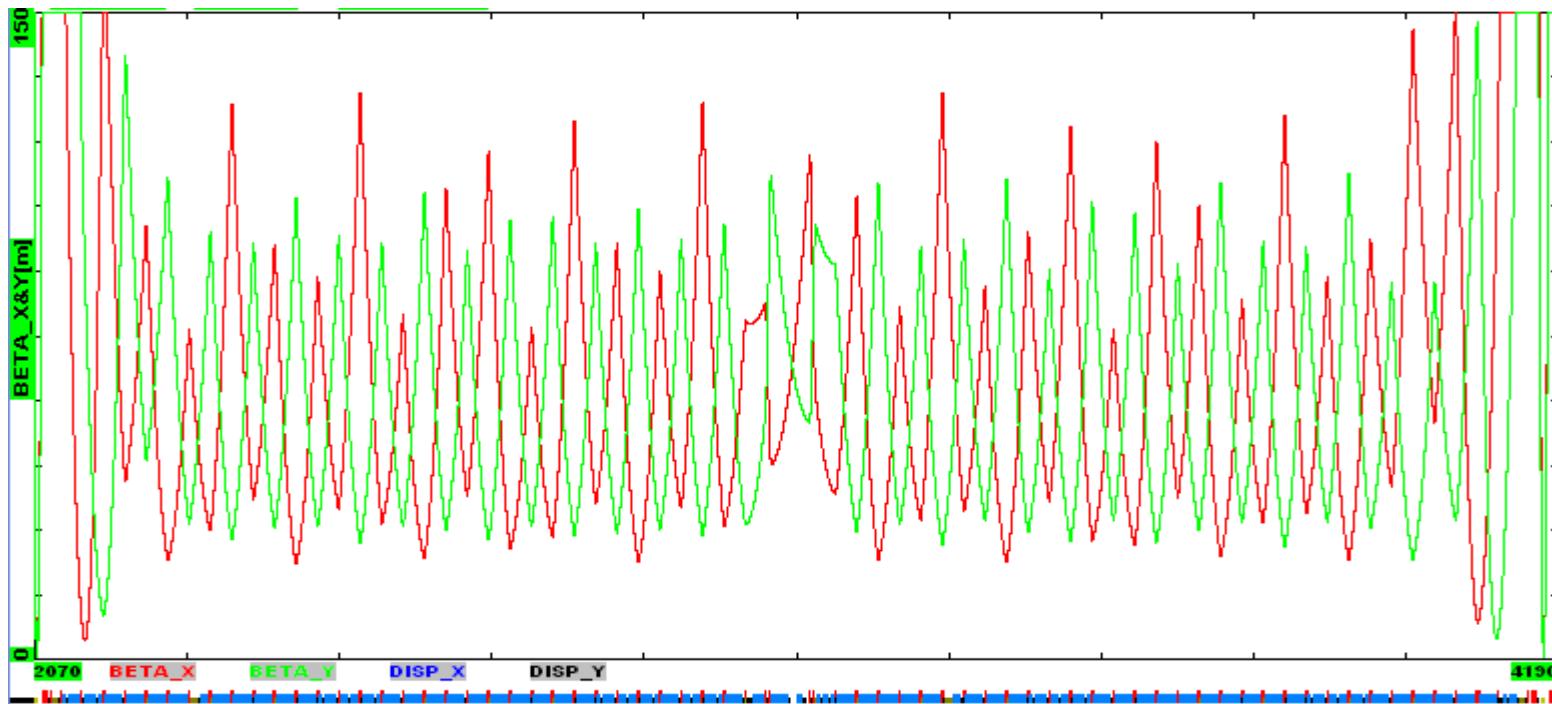
A.Valishov, All Experimenters  
Meeting

# Skew Quadrupole Errors at D16 and A38

Based on Tech data:

- At D-16, quadrupole TQ184D has the lugs set incorrectly for the roll angle. If we call the correct orientation straight up, when the lugs are set level the field is pointing **12 mr** toward the aisle.
- At A-39, quadrupole TQ096D has the lugs set incorrectly for the roll angle. If we call the correct orientation straight up, when the lugs are set level the field is pointing **10 mr** toward the aisle.

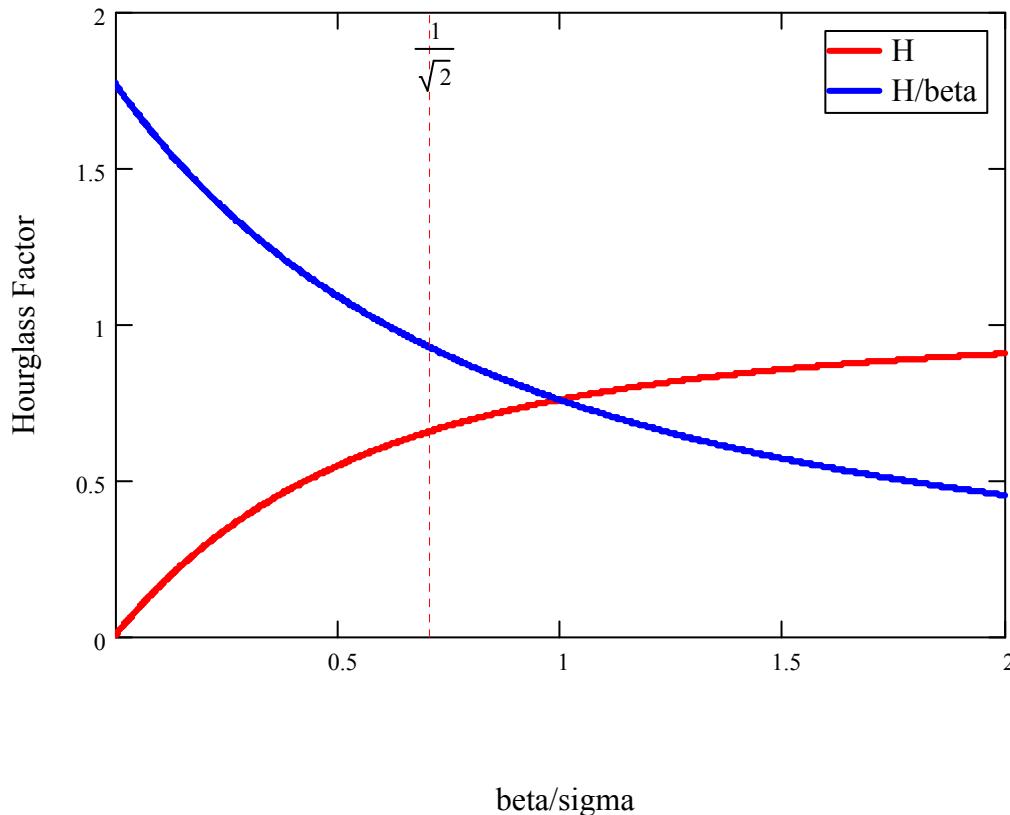
# Present Beta Functions



	$\beta_x^*$ (cm)	$\beta_y^*$ (cm)	
CDF	32.0	37.1	$\pm 5\%$
D0	35.8	40.0	$\pm 5\%$

# Lattice and Luminosity

$$L = \frac{N_p N_a f \cdot H(\beta^* / \sigma)}{2\pi \sqrt{\sigma_{p,x}^2 + \sigma_{a,x}^2} \sqrt{\sigma_{p,y}^2 + \sigma_{a,y}^2}} = \frac{N_p N_a f \cdot H(\beta^* / \sigma)}{2\pi \sqrt{\varepsilon_{p,x} \beta_{p,x} + \varepsilon_{a,x} \beta_{a,x}} \sqrt{\varepsilon_{p,y} \beta_{p,y} + \varepsilon_{a,y} \beta_{a,y}}}$$



$$\rightarrow \frac{N_p N_a f \cdot H(\beta^* / \sigma)}{2\pi (\varepsilon_p \beta_p + \varepsilon_a \beta_a)}$$

$$\rightarrow \frac{N_p N_a f}{4\pi \varepsilon} \frac{H(\beta^* / \sigma)}{\beta^*}$$

$$\beta(z) = \beta^* + z^2 / \beta^*$$

Beta\* 35cm  $\rightarrow$  28cm  
gain is 11% not 25%!

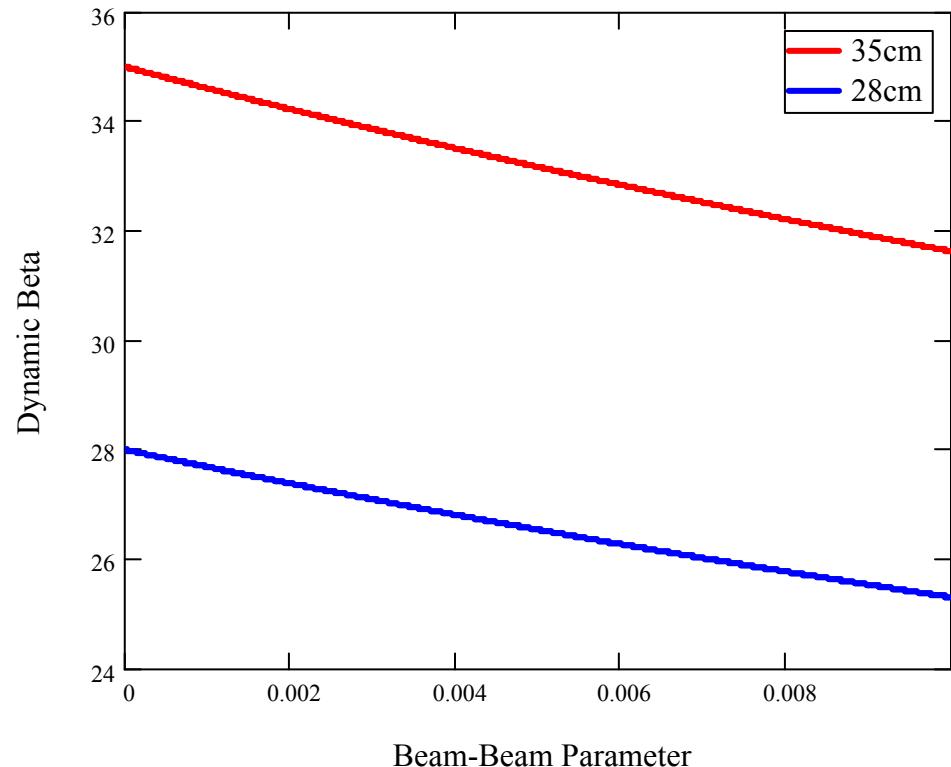
# Dynamic Beta Effect

Beam-Beam parameter  $\xi = \frac{N_p r_p}{4\pi \epsilon_p} = 0.01$

$$M = \begin{pmatrix} \cos \mu & \beta^* \sin \mu \\ -\frac{1}{\beta^*} \sin \mu & \cos \mu \end{pmatrix} \begin{pmatrix} 1 & 0 \\ -\frac{4\pi}{\beta^*} \xi & 1 \end{pmatrix}$$

$$\mu' = \mu + 2\pi\xi$$

$$\beta' = \beta^* \frac{\sin \mu}{\sin \mu'}$$

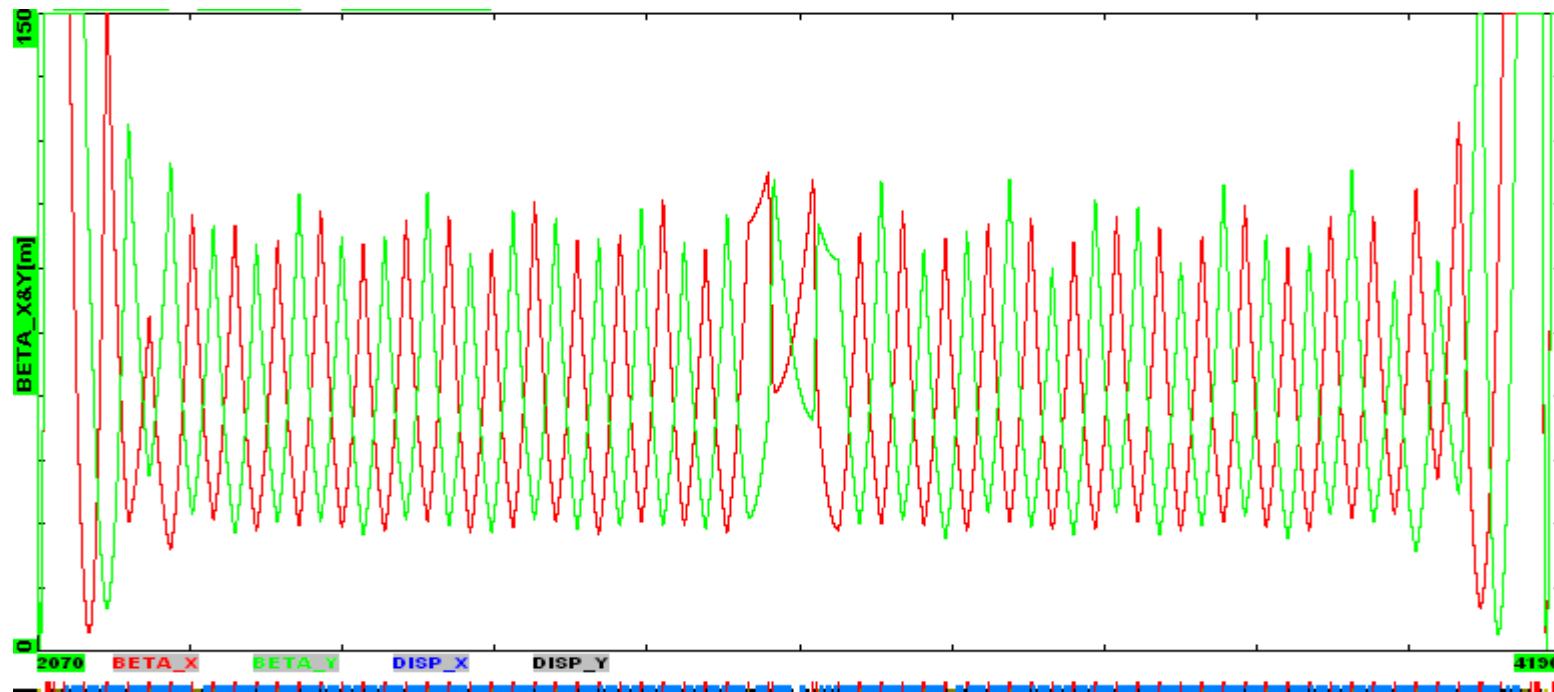


# The Proposed Optics Correction

- Decrease beta\* from 35 to 28 cm
- Eliminate difference between B0 and D0 IPs
- Correct beta-beating in the arcs

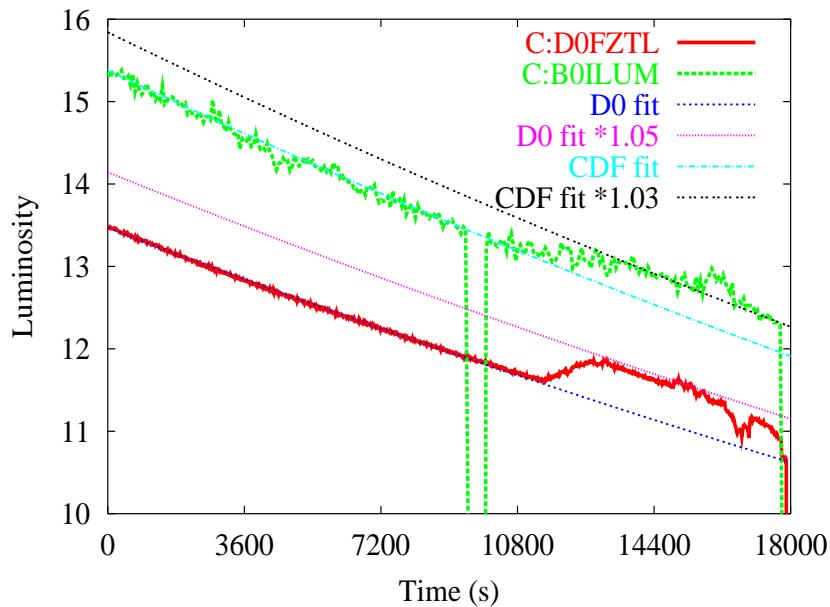
Element	Present I (A)	Delta I (A)	New I (A)
C:AQ0F	100.7	100	200.7
C:AQ9F	555.6	-50	505.6
C:AQ7F	602.6	100	702.6
C:B0Q6F	3647.4	780	4427.4
C:B0QT6F	-22.9	5	-17.9
C:B0Q5F	1972.5	-30	1942.5
C:B0Q2F	4718.9	-2	4716.9
C:B0QT2F	5.4	0.5	5.9
C:B0Q3F	4655.2	-9	4646.2
C:B0QT3F	8.7	2	10.7
C:BQ7F	680.1	100	780.1
C:BQ9F	479.7	-150	329.7
C:BQ0F	49.8	70	119.8
C:CQ0F	100.7	-40	60.7
C:CQ9F	555.6	-140	415.6
C:CQ7F	601.0	80	681.0
C:D0Q6F	3647.4	490	4137.4
C:D0QT6F	-22.9	5	-17.9
C:D0Q5F	1972.5	280	2252.5
C:D0Q2F	4704.8	-1	4703.8
C:D0QT2F	31.2	2	33.2
C:D0Q3F	4631.7	-9	4622.7
C:D0QT3F	31.6	0	31.6
C:DQ7F	654.5	60	714.5
C:DQ9F	479.7	-40	439.7
C:DQ0F	46.3	80	126.3

# Beta Functions After Correction

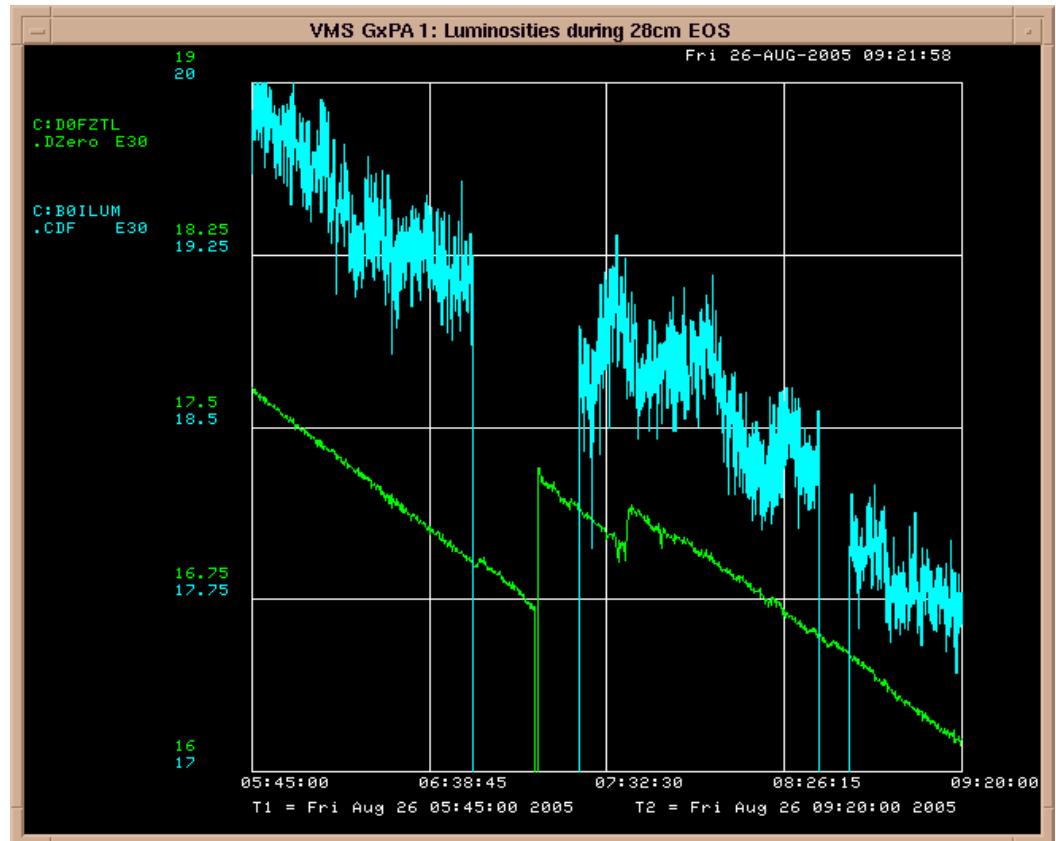


	$\beta_x^*$ (cm)	$\beta_y^*$ (cm)	
CDF	30.3	29.1	$\pm 5\%$
D0	29.2	28.2	$\pm 5\%$

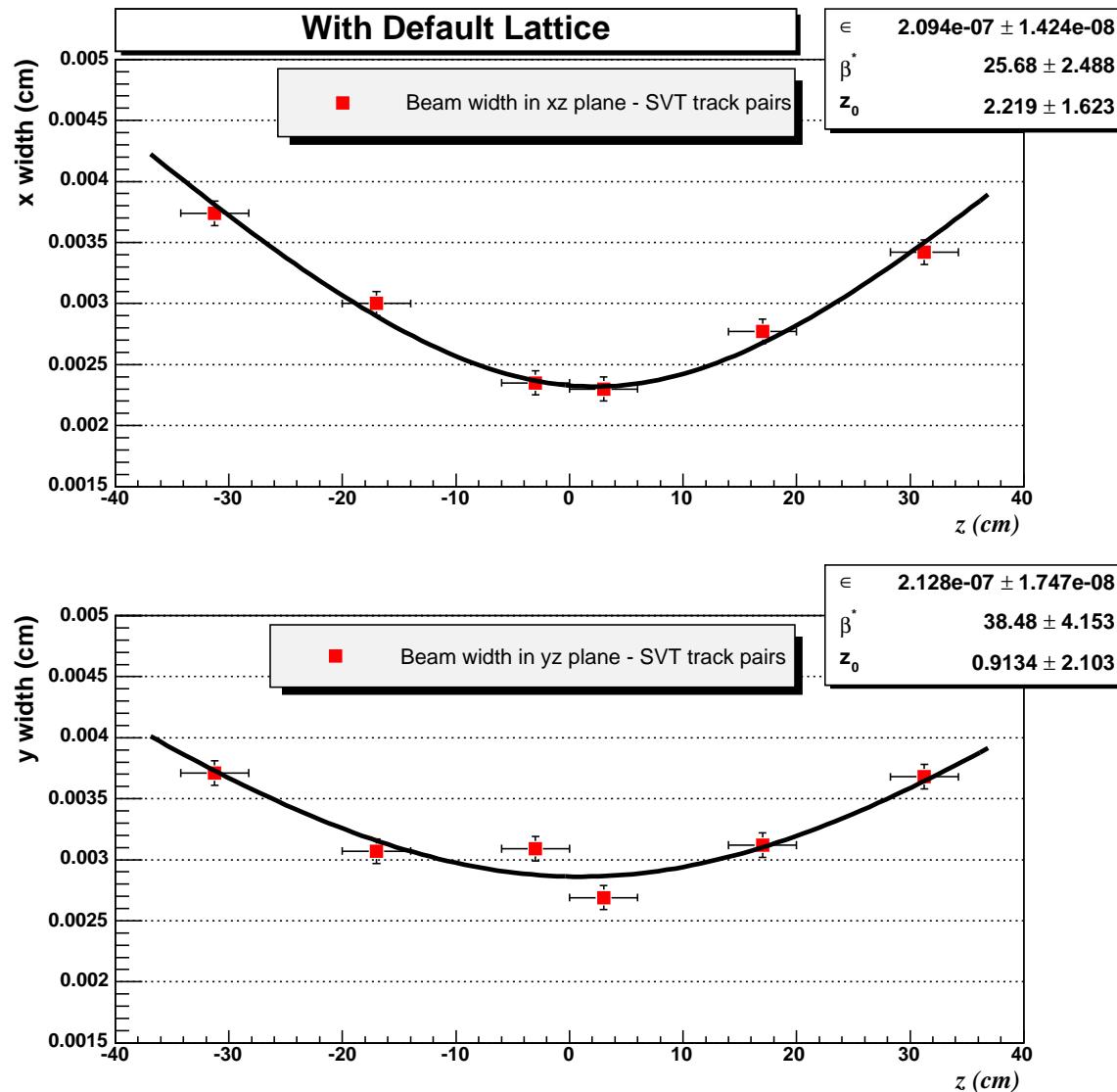
# End of Store Studies 8/4 and 8/26



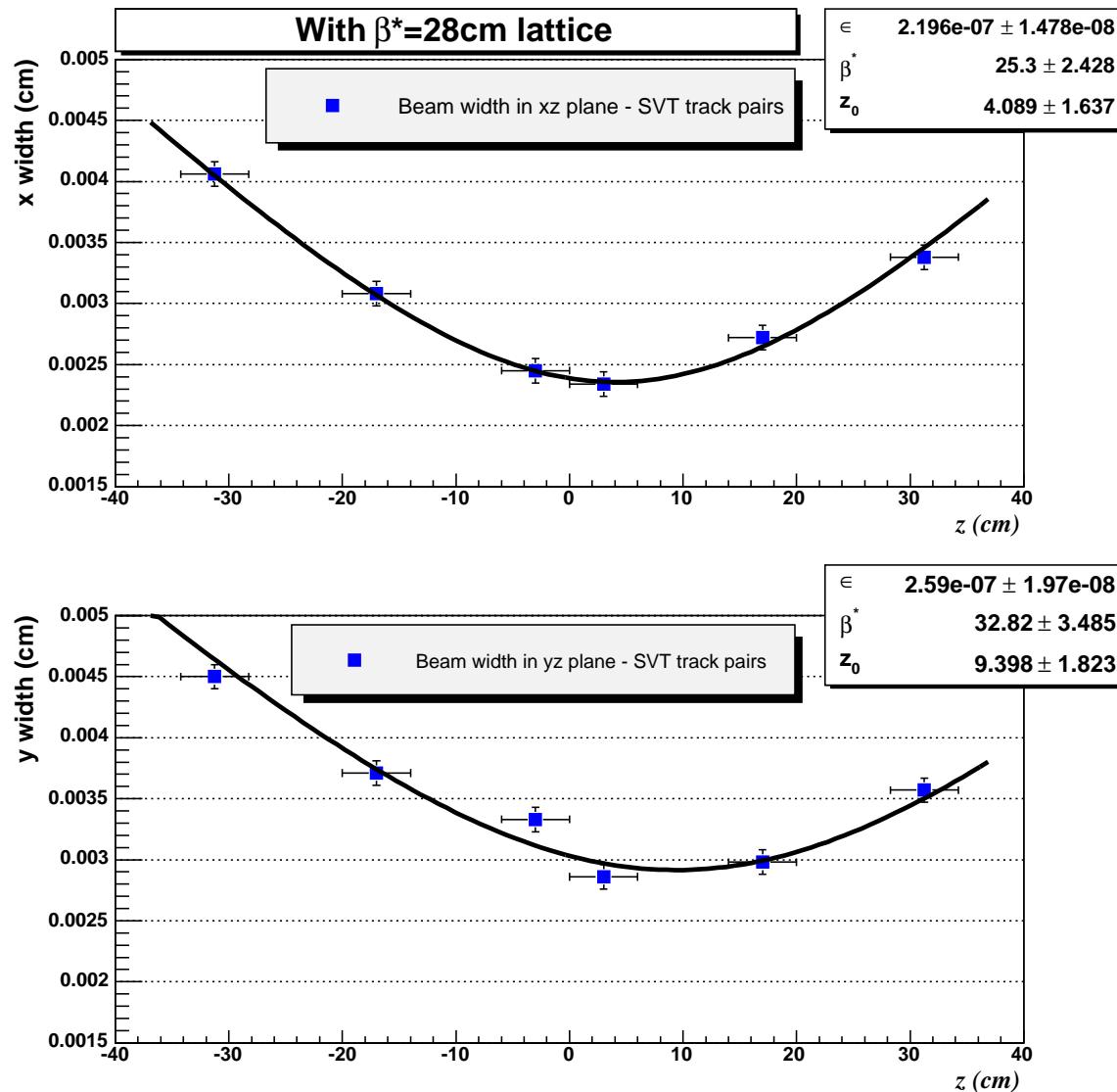
Fast (30 s) transition to the new optics with sequencer works.  
No increase of losses.  
Luminosity gain was ~3% in CDF,  
~5% in D0.



# CDF Measurement of $\beta^*$ in 8/26 EOS (Chris Neu)



# CDF Measurement of $\beta^*$ in 8/26 EOS (Chris Neu)



# Summary

- Response matrix fit method with the new BPM system allows beta function measurement with the accuracy of 5%
- The optics modification has been developed in order to:
  - Correct beta-beating in the arcs
  - Eliminate the difference between the two IPs
  - Decrease the beta\* from 35 to 28 cm
- Expected increase of the peak luminosity is ~7% in CDF and ~12% in D0
- The new optics has been implemented during EOS Tev studies with the positive effect immediately observed
- Beta\* reduction is confirmed by CDF measurements
- The new optics is ready for use earlier in a store. Minor adjustments can be made without interference with collider operation